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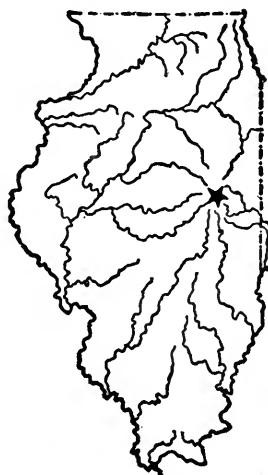
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NATIVE CRABS: THEIR BEHAVIOR
IN BREEDING

By CHARLES S. CRANDALL



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NATIVE CRABS: THEIR BEHAVIOR IN BREEDING

By CHARLES S. CRANDALL, Chief in Plant Breeding in Horticulture¹

Our native wild crabs have received frequent mention in horticultural journals and reports, and the suggestion that an improved race of apple varieties should be bred up from these crabs has been made by various writers. There are some records of experiments in hybridizing, but these are meager, do not go into details, and record nothing beyond pollination of flowers. No record of sustained effort in the direction of breeding the native crabs or of attempts to breed them on any extensive scale has been found by the writer. No apple variety known to have a native wild crab as a near ancestor has been introduced, and from the long period since the earliest suggestion of breeding the native crabs was made, it is a fair inference that the suggestion has not been acted upon and that such efforts as have been made met with failure.

Six species of native crabs are now recognized. Two of these are Pacific Coast species, one is northeastern, one southern, and two belong to the Middle West. The six species are as follows:

1. *Malus coronaria* (L.) Mill.
Malus coronaria (L.) Mill. Britton and Brown. Illus. Fl. 2, 235. 1897.
Malus coronaria (L.) Miller's Dictionary, ed. 8, no. 2. 1768.
Pyrus coronaria Linnaeus Spec., ed. 1, 480. 1753.
2. *Malus angustifolia* (Ait.) Michx.
Malus angustifolia (Ait.) Michx. Britton and Brown. Illus. Fl. 2, 234. 1897.
Malus angustifolia (Ait.) Michx. Fl. Bor. Amer. 1, 292. 1803.
Pyrus angustifolia Ait. Hort. Kew. ed. 1, 2, 176. 1789.
3. *Malus ioensis* (Wood) Britton
Malus ioensis (Wood) Britton. Britton and Brown. Illus. Fl. 2, 235. 1897.
Pyrus ioensis Bailey. Amer. Gard. 12, 473. 1891.
Pyrus coronaria var. *ioensis* Wood, Classbook, 333. 1860.
Western Crab Apple
4. *Malus soulardii* (Bailey) Britton
Malus soulardii (Bailey) Britton. Britton and Brown. Illus. Fl. 2, 235. 1897.
Pyrus soulardii Bailey. Amer. Gard. 12, 473. 1891.
Pyrus ioensis X *Pyrus malus* Bailey, L. H. Evolution of Our Native Fruits, 189. 1898.
5. *Malus fusca* (Rafin.) Schneider
Malus fusca (Rafin.) Schneider, C. K. Illus. Handb. Laubholzh. 1, 723. 1906.
Malus rivularis Roemer Syn. Mon. 3, 215. 1847.
Pyrus fusca Rafinesque. Med. Fl. 2, 254. 1830.
Pyrus rivularis Douglas. Hooker Fl. Bor. Amer. 1, 203. 1839.
6. *Malus dawsoniana* Rehder
Malus dawsoniana Rehder. Sargent, C. S. Trees and Shrubs 2, 23. 1913.
(This last was grown from seeds from *Malus fusca* collected in Oregon and is described as a hybrid between *Malus fusca* and the common apple.)

¹Retired as professor emeritus September 1, 1926.

All the older botanists include the apples in the pear genus, *Pyrus*. It was not until 1897 that Britton and Brown in their "Illustrated Flora of the Northern States and Canada" reinstated the genus *Malus*, which was first instituted by Tournefort in 1700, and thus separated the apples from the pears. Various early attempts to separate apples from pears were made, but the characters upon which separation was based did not prove reliable in all cases. The separation made by Britton and Brown is based upon the absence of grit cells in the apple and their presence in the pear. But even this character is said not to be entirely constant.

Malus coronaria is the wild crab of the northeastern states, *Malus angustifolia* is the southern crab, and *Malus ioensis* is native in the Mississippi valley. The two latter have been regarded by some as varieties of *coronaria* and the similarities are such that there is good reason for assuming close relationship. *Malus soulardii* has been thought to be a hybrid between *Malus ioensis* and the common apple, but many crabs having large fruits have been found in crab thickets in widely separated localities along streams of the Mississippi valley, just as the Soulard was found. Most of these localities are distant from cultivated orchards and the chances of cross-pollination seem remote. Some of the wild crabs found in thickets, notably the Mercer County Crab found by the late N. K. Fluke of Davenport, Iowa, have fruits larger than those of the Soulard Crab. All have their individual characteristics and they are widely different the one from the other. A number of these crabs have been known for many years, and from the fact that neither Soulard nor any of its type have found place with orchardists or nurserymen must be accepted as proof that behavior has not confirmed the numerous flattering notices that have been published concerning them.

All crab species enumerated are represented in the Station collection of breeding material and all have been used as parents in crosses.

The amount of work done, the number and variety of the crosses made, is, perhaps, not sufficient to form a perfectly stable basis upon which to found judgment as to the breeding possibilities of these native crabs; however, it is proposed to bring together in this paper, for such value as they have, the results of all crosses made that involve native crabs as parents.

1. *Malus coronaria* (L) Mill.

This native crab of the northeastern states is represented in the Station collection by only one small tree; it is on Doucain stock, grown in a 10-inch pot, was grafted February 24, 1911, and has been forced each spring in the greenhouse. The first flowers were produced in 1914; it did not flower in 1915 but bore a small number of blossoms in

each of the three following years. The flowers produced were all hand-pollinated.

Malus coronaria as the Female Parent

Beginning in 1924, 6 flowers were pollinated by pollen from Yellow Transparent and 25 flowers by pollen from Oldenburg. From the pollinations by Oldenburg 2 fruits matured; these fruits contained 7 seeds, 2 of which germinated, but the seedlings were extremely weak and both died soon after appearing above ground. Thus these two crosses of 1914 failed.

In 1916, 3 crosses were made; 5 flowers pollinated by Stayman Winesap and 4 pollinated by Akin failed entirely. Pollen of Delicious, used on 14 flowers, yielded 3 mature fruits which contained 9 seeds, 3 of which germinated. The three seedlings were planted in the nursery. At the close of 1917 two of the seedlings were living, one graded as fair and one as poor. Both seedlings were alive in the fall of 1918; the one graded as fair in 1917 had improved and was graded as good, the one rated as poor remained poor. In 1919 both graded as poor. In subsequent years they maintained the same grade with scarcely perceptible growth and finally in 1924, the eighth year from seed, both died. These trees from the time of germination, were plainly deficient in vitality, but they continued to live until during the eighth year.

In 1917 pollen of Jonathan was applied to stigmas of 15 flowers, and 5 fruits containing 13 developed seeds were matured. Of the 13 seeds 7 germinated and 6 seedlings survived the first season; 1 graded as fair and 5 as poor. In the fall of 1919 all were living and were graded as in 1918. In 1920, 2 graded as fair and 4 as poor. In 1921 one died; one of those remaining was fair and 4 were poor. The next year another died and the 4 remaining all graded as poor. In 1923 one died; 2 of those surviving were graded poor and 1 fair. In 1924 two seedlings were living, both graded as poor. At the close of the season of 1925 only one seedling was living. This tree, at the end of its eighth year measured 4 feet 1 inch high, had a spread of 4 feet 2 inches, a trunk diameter of 1.1 inches, and was graded as poor.

One other cross was made in the greenhouse in 1918 in which 5 flowers of *M. coronaria* were pollinated by pollen of Twenty Ounce. No fruits matured.

Thus the net result from the use of pollen of seven varieties on an aggregate of 74 flowers of *M. coronaria* is one feeble seedling from the 1917 cross by Jonathan that, from its appearance, may be with certainty predicted to die within the course of the next, its ninth year from the seed.

All seedlings from crosses in which *M. coronaria* was the female parent have been characterized by extreme debility; from the time of first appearance none gave any promise of living to fruiting maturity,

and the wonder is that any of them lived as long as they did. It is of course possible that should a large number of seedlings be grown, individuals possessed of reasonable vitality might appear, but from experience thus far gained it appears that want of vitality in seedling progeny is a complete bar to improvement in apple varieties thru use of *M. coronaria* as the female parent in crosses.

Record of these crosses in which *M. coronaria* was the female parent is given in tabular form in Table 1.

Malus coronaria as the Male Parent

The same tree that was used as the female parent in the crosses above mentioned supplied pollen which was used on 34 flowers of 6 orchard varieties and 1 crab. The pollen applied to stigmas of 5 flowers of Yellow Transparent, 5 flowers of Akin, and 4 flowers of Winesap in 1914, failed entirely; no fruits developed.

In 1916 pollen was used on 8 flowers of Stayman Winesap and this also failed. In 1917, 4 flowers of *M. soulardi* pollinated by *M. coronaria* pollen failed. Two flowers of Grimes supplied with *coronaria* pollen produced one fruit which contained 3 seeds. Two of the seeds were planted; both germinated and one seedling lived to be planted in nursery. This seedling is still living, has grown with reasonable vigor, and promises to live to fruiting maturity. At the end of its eighth year, 1925, the tree stands 4 feet 4 inches high, has a spread of 7 feet 8 inches, and a trunk diameter of 1.1 inches. In 1918, 6 flowers of Twenty Ounce were pollinated by pollen of *M. coronaria* and 1 fruit matured but it contained no viable seeds. Thus the results for this group of crosses in which pollen of *M. coronaria* was used on 6 varieties and 1 crab and involving 34 pollinations and the production of 2 fruits, is one seedling of the cross on Grimes, which is now eight years old and will probably reach fruiting maturity.

The record of this group is given in Table 2.

2. Malus angustifolia (Ait.) Michx.

This species, known as the Narrow-Leaved Crab or the Crab of the South, has been given what may serve as a fair trial in breeding and has met with practical failure. This failure may be ascribed to low vitality. Growth of scions used in grafting has been in all cases slow and feeble, and most grafts have died within one or two years.

The first scions of the species were received in January, 1907, but they had been dried in transit and after storage under proper conditions only one scion appeared to survive; this was root-grafted on apple seedling stock in March. The scion made a slow, feeble start, was noted as living on July 20, but died before the end of the season. Other scions were received in January, 1908, and on the 17th of that month 10 root-grafts on seedling stocks were made. In the spring 10

TABLE 1.—*Malus coronaria* AS FEMALE

Male parent	Year of cross	Flowers pollinated	Fruits matured	Percent age of success	Number of seeds Planted	Percent germinated	Seedlings planted in nursery	Trees living							
								'17	'18	'19	'20	'21	'22	'23	'24
Yellow Transparent.....	Gh. 1914	6	0	8.00	7	2	28.57	0	..	..	..	..	..	..	..
Oldenburg.....	Gh. 1914	25	2	..	..	..	..	..	..	..	..	..	..	..	..
Stayman Winesap.....	Gh. 1916	0	..	..	..	..	..	..	..	..	..	..	..	..	..
Delicious.....	Gh. 1916	14	3	21.43	9	3	33.33	3	2	2	2	2	0	0	..
Akin.....	Gh. 1916	4	0	..	..	..	..	..	..	..	..	..	..	..	..
Jonathan.....	Gh. 1917	15	5	33.33	13	7	53.85	7	..	..	..	..	..	..	..
Twenty Ounce.....	Gh. 1918	5	0	..	..	..	..	..	..	..	..	..	..	..	..
Total.....		74	10	13.53	29	12	41.37	10	..	..	..	..	..	..	1

TABLE 2.—*Malus coronaria* AS MALE

Female parent	Year of cross	Flowers pollinated	Fruits matured	Percent age of success	Number of seeds Planted	Germi-nated	Percent germinated	Trees living							
								'18	'19	'20	'21	'22	'23	'24	'25
Yellow Transparent.....	Gh. 1914	5	0	....	..	..	....	..	..	..	..	..	..	..	..
Akin.....	Gh. 1914	5	0	....	..	..	....	..	..	..	..	..	..	..	..
Winesap.....	Gh. 1914	4	0	....	..	..	....	..	..	..	..	..	..	..	..
Stayman Winesap.....	Gh. 1916	8	0	....	..	..	....	..	..	..	..	..	..	..	..
<i>Malus soudanica</i>	Gh. 1917	4	0	50.00	..	..	..	..	..	..	..	..	..	..	..
Grimes Golden.....	Gh. 1917	2	1	..	..	..	..	..	..	..	..	..	..	..	..
Twenty Ounce.....	Gh. 1918	6	1	16.67	0	..	100.00	..	..	..	..	..	..	..	..
Total.....		34	2	5.85	2	2	100	1	..	..	..	..	..	..	..

top-grafts were made from the remainder of the scion wood on a small tree of Sops of Wine.

The root grafts were planted in the nursery in early spring. In the fall of 1908, when lifted for winter storage, three of the scions were living; they were again planted in the spring of 1909 and started feeble growth, but all were dead before the end of the season. Of the top-grafts, 6 started growth in 1909 and were living on July 10, but the growth made was small and weak; all were dead when examined October 4, 1910.

Death of these grafts eliminated the species from the collection.

Again in 1912 scions were obtained, and on January 10 ten scions were grafted as root-grafts on apple seedlings and two scions were worked as top-grafts on Paradise stocks in pots. Most of these grafts started and made feeble growth, but none endured beyond the third year.

In 1914 scions were inserted on potted Doucin stocks for use in the greenhouse. One of these grafts flowered sparingly in March, 1918. Pollen of Twenty Ounce was used on 25 flowers and 9 flowers were pollinated by Fameuse. From the Twenty Ounce pollinations 2 fruits and from the Fameuse pollinations 1 fruit matured. The average of these fruits weighed 16 grams, measured 27 mm. in vertical diameter, 33 mm. in transverse diameter, and contained 6½ seeds.

The two fruits from the cross by Twenty Ounce contained 13 seeds, 8 of which germinated, and 3 seedlings lived to be planted in nursery. These seedlings were very weak; two of them died during the second year and the remaining one in the third year.

The one fruit from the cross by Fameuse contained 6 seeds, 5 of which germinated, and 5 seedlings were planted in nursery. Two of these died the first year, 2 the second year, and 1 was still living in 1925, at the end of its seventh year.

This tree was graded as fair in 1925; it is 4 feet 6 inches high, has a spread of 2 feet and a trunk diameter of .9 inch. The dimensions at the end of the seventh year show the slow, feeble growth. The one living tree may survive until it produces fruit but this is doubtful.

Table 3 brings together the record of the two crosses.

Malus angustifolia as the Male Parent

Only one attempt to use pollen of *M. angustifolia* has been made. Four flowers of Twenty Ounce were pollinated by *M. angustifolia* in 1918, but no fruits developed.

From the tests here recorded there is no encouragement that *M. angustifolia* can be used with success in breeding; this is chiefly because of its slow, feeble growth, and because the seedling progeny is so deficient in vitality that they cannot survive to fruiting maturity.

TABLE 3.—*Malus angustifolia* AS FEMALE

Male parent	Year of cross	Flowers pollinated	Fruits matured	Percent- age of success	Planted	Number of seeds Germi- nated	Percent- age ger- minated	Seedlings planted in nursery	Trees living
Twenty Ounce	Gh. 1918	25	2	8.00	13	8	61.54	3	1
Fameuse	Gh. 1918	9	1	11.11	6	5	83.33	5	1
Total . . . . .	.....	34	3	8.82	19	13	68.42	8	1

TABLE 4.—ENDURANCE OF SEEDLINGS IN WHICH *Malus ioensis* IS THE FEMALE PARENT

Male parent	Year of cross	Seed-lings pro-duced	Died before nursery	Died in nursery						Died in orchard				Seed-lings living in 1925
				1st year	2d year	3d year	4th year	5th year	6th year	.....	.....	.....	.....
Collins	1915	31	2	14	5	4	2	4	.....	.....	2	1	1	0
Jonathan	1916	165	5	39	50	25	18	11	6	2	2	1	1	8
Wealthy	1917	28	3	16	3	2	0	1	0	0	0	0	0	3
Pewaukee	1917	131	76	34	8	5	2	0	0	1	1	1	1	5
Ben Davis	1918	100	11	72	5	4	6	1	0	0	0	0	0	0
Rome	1921	14	4	4	0	0	0	0	0	0	0	0	0	2
Total . . . . .	.....	469	101	179	75	40	28	16	8	2	2	2	2	18

3. *Malus ioensis* (Wood) Britton

The Western Crab-Apple, or Prairie States Crab, is native in Illinois and surrounding states of the Mississippi valley, and is represented in the Station collection by two trees, now eighteen years from root-grafts made in 1908, that have been bearing fruit for the past twelve years.

Malus ioensis as the Female Parent

The flowers of *M. ioensis* have been pollinated in five different years by pollen from six orchard varieties and each cross has matured some fruit. The percentages of success in fruit production have ranged from 18.37 for a 1915 cross by Collins to 49.18 for the 1921 cross by Rome. The other varieties used as pollen parents are Jonathan, Wealthy, Pewaukee, and Ben Davis. The total of pollinations made is 469 and the total of fruits matured is 181, 38.59 percent of all pollinations being successful.

It may be stated here that the average success percentage for all crosses that have been attempted in the apple-breeding work is approximately 25. For the group under consideration four of the crosses have success percentages far above this average, while two of the crosses fall somewhat below.

The success percentage for the group is sufficiently above the general average to place this species in the class of what may be called good breeders, at least so far as fruit production is concerned, but it should be kept in mind that the ultimate success of a cross involves other things than fruit production. Hybrid fruits must contain seeds; seeds must have power to germinate; and seedlings must have the vigor that will insure production of other fruits with viable seeds from which may come the next generation.

Seed Production.—The 181 fruits from the six crosses contained 1,049 apparently good seeds, or 5.79 to each fruit. For the different crosses the seed production ranged from 4.26 to each fruit for the 15 fruits of the Wealthy cross, to 6.82 seeds to each fruit for the 35 fruits of the Ben Davis cross. The seed average, as ascertained for 312 open-pollinated fruits of this species, was 4.19 seeds to each fruit; hence the average attained in these crosses may be regarded as good for fruits of the crab class.

Germination.—Of the total of 1,049 seeds planted 469, or 44.73 percent, germinated. For the different crosses, the one by Rome had the lowest percentage; of 192 seeds planted only 14, or 7.29 percent, germinated. Seeds of the cross by Pewaukee had the highest percentage; of 207 seeds 131, or 63.28 percent, germinated.

Endurance of Seedlings.—In this group of crosses in which *M. ioensis* was the female parent there was a considerable number of seedlings so deficient in vitality that they died before the time for

transfer to nursery. Of the 469 seedlings that appeared above ground, 368 were planted in nursery. This indicated that 101, or 21.53 percent of the seedlings, died in the first stage of existence. This loss was very unevenly distributed among the various crosses and ranged from a loss of 2 of 31 seedlings, or 6.45 percent of the Collins cross of 1915, to 76 of 131 seedlings, or 58.01 percent for the Pewaukee cross of 1917. Planting in nursery did not end the losses; trees continued to die at a rapid rate.

Of the 368 seedlings planted in nursery, 179 died the first year, 75 the second year, and 40 the first year in orchard. The older seedlings from the earlier crosses died in gradually decreasing numbers in following years. Seedlings of the last cross made, that by Rome in 1921, are four years old and have record of only two years in orchard, while seedlings of the 1916 cross by Jonathan are nine years of age and have record of seven years in orchard. Total losses for the six crosses to the end of the season of 1925 were 451, or 96.16 percent of the seedlings produced; this leaves only 18 living seedlings distributed in four crosses. The last of the 31 seedlings of the earliest cross by Collins in 1915 died during the third year in orchard. The last of 100 seedlings of the Ben Davis cross of 1918 died in its fourth year in orchard. It follows that only the crosses of Jonathan, Wealthy, Pewaukee, and Rome are now represented by living seedlings.

Details of the passing out of the seedlings of the crosses under consideration are brought together in Table 4.

Thus at the end of 1925 a fraction over 96 percent (96.16) of the seedlings were dead; all died for the same reason—*inherent weakness*. They had not sufficient vitality to live and died more or less promptly.

The present condition of the remaining seedlings may now be examined.

The oldest cross represented is that of Jonathan made in 1916. This cross produced 165 seedlings; at the end of 1925, the ninth year, 157, or 95.15 percent, had died and 8, or 4.85 percent, were living. These 8 seedlings ranged in height from 10 inches to 6 feet 4 inches with an average of 3 feet 2 $\frac{3}{4}$ inches; in spread, from 0 to 3 feet 2 inches with an average of 1 foot 2 inches; and in diameter, from .3 inch to .9 inch with an average of .5 inch. Six of the trees graded as poor, one as fair, and one as good; none have flowered. The six trees graded as poor are destined to die soon; the other two may possibly survive to fruit production, but even the tree graded as good shows its lack of vitality in its growth performance thru nine years of life.

The next cross is that of Wealthy made in 1917. Starting with 28 seedlings, produced during its eight years of existence, 25, or 89.29 percent, have died and only 3, or 10.71 percent, survive. These range in height from 1 foot 10 inches to 14 feet 2 inches, in spread from 1 foot 4 inches to 12 feet 6 inches, and in diameter from .3 inch to 3.8

inches. Two of the trees are graded as poor, one as good. This one good tree presents a strong contrast to the two others. It has made vigorous growth from the beginning. In 1925, at eight years of age, its dimensions are: height, 14 feet 2 inches; spread, 12 feet 6 inches; and diameter, 3.8 inches. It is symmetrical in form and foliage and general characteristics closely resemble well-grown trees of the mother parent, *M. ioensis*. This tree flowered in 1925, its eighth year, with most flowers fully open on May 6. On April 18 fifty buds were emasculated and two days later, on April 20, pollen of Wealthy was applied to the stigmas. The pollinations were 26 percent successful and 13 fruits matured. Characteristics of these fruits were as follows:

	Weight	Vertical diameter	Transverse diameter
Largest fruit.....	98.84 grams	53 mm.	62 mm.
Smallest fruit.....	57.44 grams	45 mm.	52 mm.

The largest fruit contained 8 seeds, the smallest 2 seeds. One fruit had the seeds destroyed by insects. The other 12 fruits contained 49 seeds, an average of 4.08 to each fruit.

In color the fruits were self-green, as in the female parent; calyx lobes uniformly persistent, as in both parents. Stems varied from 22 mm. to 30 mm. in length. Flavor sharply subacid, very juicy; quality poor, crab-like. While the hand-pollinated fruits were all self-green as in the female parent, there were open-pollinated fruits on the tree that displayed a light red blush, which in some instances spread over half the surface of the fruit. The blushed fruits were picked and described October 7. The three specimens from which description was made averaged 78.22 grams in weight, 44 mm. in vertical diameter, 57 mm. in transverse diameter, and contained 5 seeds. In form the fruits were oblate-roundish. For convenience in comparing weight and dimensions of the hybrid fruits with weight and dimensions of fruits of the two parents, as determined from open-pollinated fruits borne by the plants, the data are brought together here in tabular form:

	Number of fruits averaged	Average weight grams	Average vertical diameter in mm.	Average transverse diameter in mm.	Average seed content
<i>Malus ioensis</i>	312	9.02	23	26	4.19
Wealthy.....	1013	97.04	51	64	8.02
Hybrid fruits.....	13	76.64	49	56	4.08

In form the hybrid fruits are like the female parent; in weight and diameters they approximate the male parent; and in seed content they fall far below the male parent and slightly below the female parent. The 49 seeds from the 12 hybrid fruits of this back cross were planted in December, 1925, and the germination record, as taken

in April, 1926, shows that 31 of the seeds germinated and that 26 of the seedlings lived to be planted in nursery. In the fall of 1926 there were 17 seedlings living; these were taken up for winter storage, and all were again planted in nursery in May, 1927. The best one of the 17 seedlings is 15 inches high and is graded as good; 2 others, one 10 the other 11 inches high, are graded as fair; the others, 14 in number, are all very small and are graded as poor. From experience it may be predicted that the 14 seedlings now rated as poor will die in this or the following year; the 2 rated as fair will linger for a longer period, or may even improve and survive to fruiting, and the one individual, which, from its evident vigor, is rated as good, should continue to the full development of a normal apple seedling.

The two surviving trees of this cross, *M. ioensis* X Wealthy, that are graded as poor, are in the same class with those that have died. They have been deficient in vitality from the beginning, as is shown by the annual increments, and they are destined to die within a short time, leaving the one tree that possessed vitality to grow and continue producing fruit as the sole representative of the cross.

The cross of Pewaukee, also of 1917, produced 131 seedlings from the 207 seeds planted, and at the end of 1925, the eighth year, 5 were living. Here the loss amounted to 126 seedlings, or 96.18 percent of the number produced, and of the 5 seedlings remaining in 1925 4 graded as poor and 1 as fair. The growth increment of all the trees has been small in each year, and while the one tree now graded as fair may live to fruiting, the others are not likely to attain that end.

From the growth record of 1925, at the end of the eighth year, it is found that the 4 trees graded as poor have an average height of 3 feet, an average spread of 2 feet 9 inches, and an average diameter of .5 inch; and that the tree graded as fair is 7 feet 6 inches high, has a spread of 7 feet 2 inches, and a trunk diameter of 1.4 inches. For eight-year-old trees this is a poor performance and plainly shows the deficiencies in vitality.

There remains the 1921 cross by Rome. This is represented by 2 seedlings, all that are living of the 14 produced. The loss here is 85.70 percent; 4 seedlings having died before transfer to nursery, 4 during the first year in nursery, and 4 during the second year. The two remaining were graded as good; their average height was 3 feet 4 inches, there was no spread, and the average diameter was .45 inch. The next year, 1924, the average height was 3 feet 8 inches, average spread 8 inches, and average diameter .5 inch; one graded as good the other as fair. For the last year, 1925, both trees graded as good, had an average height of 4 feet, an average spread of 1 foot 6 inches, and an average diameter of .7 inch. The appearance of the two surviving trees of this cross at the end of the fourth year suggests that they may live to fruiting age altho the growth performance indicates vigor less than normal.

TABLE 5.—*Malus ioensis* AS FEMALE

Male parent	Year of cross	Flowers pollinated	Fruits matured	Percent age of success	Number of seeds Planted	Germminated	Percent- age germinated	Seedlings planted in nursery								Trees living				
								'16	'17	'18	'19	'20	'21	'22	'23	'24	'25			
Collins.....	1915	49	9	18.37	54	31	57.41	29	15	10	6	4	0	17	11	9	8	8		
Jonathan.....	1916	136	56	41.18	293	165	56.31	160	121	71	46	28	6	4	4	3	3	3		
Wealthy.....	1917	74	15	20.27	64	28	43.75	25	.	9	6	4	4	4	3	3	3			
Pewaukee.....	1917	76	36	47.36	207	131	63.28	55	.	21	13	8	6	6	6	6	5			
Ben Davis.....	1918	73	35	47.94	239	100	41.84	89	.	17	12	8	2	1	0	2	2			
Rome.....	1921	61	30	49.18	192	14	7.29	10	.	.	.	.	.	.	.	.	.
Total.....	.....	469	181	38.59	1049	469	44.70	368	.....	.....	.....	.....	.....	.....	.....	.....	.....	18		

Of the 18 seedlings remaining in four of the six crosses made, 13 are graded as poor and are quite certain to die before fruiting, as did so many others. Three seedlings graded as fair, and it may be hoped rather than expected that these survive to fruiting age. Of the 3 that rate as good, one has fruited and the others will probably attain this end within one or two years.

The record of this group of crosses is brought together in tabular form in Table 5.

Experience with these crosses, in which *M. ioensis* was the female parent, does not encourage the view that this species of our native crabs can be successfully used as a basis for the improvement of apple varieties. The reason does not rest in failure to produce fruits from flowers pollinated, for these crosses show that 38.50 percent of the pollinations made were successful and this is far above the average for all crosses. There was no deficiency in seed production, for the seed average was 5.79 seeds from each fruit; nor does the difficulty lie with germination, for nearly 45 percent of the seeds germinated. Inspection of the seedlings at once gives the reason for failure. In the crosses made, vitality sufficient for existence is not transmitted to the offspring; the seedlings die immediately after germination, or they make a feeble growth for a few years and then die because they have not vitality enough to live.

No attempts to use *M. ioensis* as the male parent have been made, chiefly because of its late blooming habit.

4. *Malus soulardii* (Bailey) Britton

The Soulard Crab originated in the Mississippi valley near St. Louis more than sixty years ago. It has been the subject of much discussion, and botanists have expressed very different views as to its proper position in botanical classification. It has often been referred to as a hybrid arising from pollination of flowers of *M. ioensis* by pollen of the common apple, or from flowers of *M. coronaria* by the common apple. In 1891 Bailey described it and gave it rank as a new species—*Pyrus soulardii*—in the *American Garden*. Britton and Brown recognized it, transferred it to the genus *Malus*, and included it in the “Illustrated Flora of the Northern States and Canada” as *Malus soulardii*, in 1897. In 1898 Bailey in his “Evolution of Our Native Fruits” reverses his former judgment and says, “I confess to a belief that *Pyrus soulardii* is not a true species, but is a hybrid between *Pyrus ioensis* and the common apple, *Malus malus*.”

The writer is content to allow *Malus soulardii* to stand as a distinct species; at all events it is so distinctly different from any other form of *Malus* in the Station collection that there is no danger of confusing it with any of them. *M. soulardii* is only one of a considerable number of large-fruited wild crabs that have been discovered in

crab thickets in various localities along the streams of the Mississippi valley. An example of these crabs is found in the Mercer County Crab, which was discovered by the late N. K. Fluke of Davenport, Iowa. This is represented in the Station collection by several trees; they are quite different from *M. soulardii* in form and size and particularly in the leaves; the fruit is of about the same form and color as the fruit of *M. soulardii*, but is larger. Thus, the average weight of 425 fruits of *M. soulardii* is 38 grams, while the average of 822 fruits of Mercer County Crab is over 80 grams; diameters of fruits of *M. soulardii* are 34 mm. vertical by 41 mm. transverse, and for the Mercer County Crab they are 47 mm. vertical by 59 mm. transverse.

M. soulardii is characterized by extreme vigor of growth in its earlier years, by strictly erect habit, which is modified under heavy crops of fruit until the trees spread widely. The leaves are large, broadly ovate, oblong or elliptical, very dark green, and conspicuously rugose.

Malus soulardii as the Female Parent

This species has been used as the female parent in 26 crosses with 13 orchard varieties and 3 crab forms. Flowers pollinated for all crosses number 575. Five crosses, with 340 pollinations, were on trees in orchard and 21 crosses, with 235 pollinations, were on potted dwarfs in the greenhouse. Sixteen of the crosses, with 283 pollinations, matured no fruits. The 10 others, with an aggregate of 292 pollinations, matured 52 fruits, which ranged, in numbers to each cross, from 1 to 19. It thus appears that 9.04 percent of all pollinations made were successful so far as fruit production is concerned. Of the 10 crosses producing fruits, 2 had one fruit each, and neither fruit contained seeds; these were both greenhouse crosses of 1916, one by Fanny, the other one of four crosses by Yellow Transparent. The one fruit from the greenhouse cross by Winesap in 1914 contained 3 seeds, but these did not germinate. The Oldenburg cross in orchard in 1915, from 49 pollinations, matured 2 fruits containing 6 seeds, 3 of which germinated, but all three of the seedlings died in the second year.

The Oliver cross, made in the greenhouse in 1916, from 6 pollinations matured 3 fruits containing 5 seeds, 1 of which germinated, but the seedling died in its second year.

The greenhouse cross by Oldenburg in 1918 from 22 pollinations matured 2 fruits containing 2 seeds, 1 of which germinated. The seedling was very weak, but lingered until in its fourth year, when it died.

So there are 6 crosses to be added to the 16 that failed to mature any fruits, making 22 crosses that are not represented by seedlings. There are 4 crosses that now have living seedlings; these are the greenhouse cross by Delicious in 1916, which, from 9 pollinations, matured 1 fruit having 3 seeds, 2 of which germinated. One of the seedlings died in 1921 in its fifth year; the other is still living and in

1925, at the end of its ninth year, it lacked 1 inch of being 6 feet high, had a spread of 4 feet 8 inches, and a trunk diameter of 1.2 inches. It was graded as fair and may survive to fruiting age.

The Jonathan cross made in the greenhouse in 1917 matured 6 fruits from 10 pollinations; these contained 12 seeds, 8 of which germinated, and 7 seedlings were transferred to nursery. All these seedlings lived thru the first year, but 4 died in the second year, 1 in the fourth year, and 1 in the fifth year, leaving 1 seedling, which in 1925 completed its eighth year; it then measured 4 feet 8 inches in height, had a spread of 5 feet 6 inches and a trunk diameter of 1.5 inches. It is graded as fair and will possibly survive to fruiting.

Considering the crosses in order of time, we have next the cross of Pewaukee made in the orchard in 1917. In this cross 133 pollinations were made and 19 fruits matured; thus 14.21 percent of the pollinations made were successful in fruit production. The 19 fruits contained 55 seeds, an average of approximately 2.9 seeds to each fruit, and 34, or 61.82 percent, germinated. Five of the seedlings died very soon after germination, so that only 29 seedlings were transferred to nursery. The majority of the seedlings were very weak and indicated by their appearance that they were destined to die long before reaching fruit production. These seedlings died as follows: 2 the first year in nursery, 8 the second year, 6 in the third year or first year in orchard, 2 in the fourth year, 1 in the fifth year, and 2 in the sixth year; making a loss, from the time of removal to nursery to the end of the sixth year, of 21 seedlings, or 72.41 percent of the number planted in nursery, and bringing the total losses, from germination to the end of the sixth year, to 26 seedlings, or 76.24 percent. All these losses are rightly ascribed to inherent weakness; the seedlings did not have sufficient vitality to live, and passed out gradually.

Of the 8 seedlings living in 1925, at the end of the eighth year, 4 are graded as fair and 4 as poor. The range in height is from 10 inches to 8 feet 10 inches with an average of 5 feet 3 inches; the spread ranges from 4 inches to 6 feet 8 inches with an average of 3 feet 6 inches; and the diameter, from .4 inch to 2.7 inches with an average of 1.25 inches. These dimensions for trees that are eight years old exhibit the extremely slow growth and absence of the vigor that normal seedlings should have. The 4 seedlings rated as poor may linger a year or two longer, but they are surely destined to die before producing fruit. For the 4 rated as fair it may be hoped that they will live to bear fruit.

The last of this group of crosses is that of Oldenburg on a tree in orchard in 1917. In this case 48 flowers were pollinated and 16 fruits matured; thus exactly one-third of the pollinations were successful. The 16 fruits contained 35 seeds, an average of 2.18 to each fruit; 18 of the seeds, or 51.43 percent, germinated. The seedlings exhibited the

same weakness that characterized the seedlings of other crosses in this group having *M. soulardii* as the female parent. Six, or one-third, of the seedlings died before it was time to transfer to nursery; and of the 12 removed to nursery, 4 died the first year, 3 the second, and 1 in each of the fourth, sixth, and seventh years; making a loss of 16 seedlings, or 88.88 percent of the number when germination was completed.

Of the two seedlings that survived in 1925, at the end of the eighth year, one was 2 feet high, had a spread of 6 inches, and a trunk diameter of .4 inch; the other was 5 feet 8 inches high, had a spread of 2 feet 5 inches, and a trunk diameter of .7 inch. Both were rated as poor and altho one is nearly three times as tall as the other, has nearly five times the spread, and exceeds it in trunk diameter by 75 percent, it is not expected that either will live to bear fruits.

To summarize what has been done in the use of *M. soulardii* as a female parent.

Twenty-six crosses were made with 13 orchard varieties and 3 crab-like species of *Malus* in five different years. Some of the crosses were made in the greenhouse and some on trees in orchard, the whole involving 575 pollinations and yielding 52 fruits. Sixteen of the crosses failed in fruit production, and of the 10 crosses maturing fruits 6 failed because the fruits were seedless or the seeds did not germinate. The 52 fruits contained 121 seeds and of these 67, or 55.37 percent, germinated and 54 seedlings lived to be planted in nursery. Weak seedlings continued to die, and in the fall of 1925 only 12 seedlings of 4 crosses remained alive. One of these seedlings is nine years old and 11 are eight years old. Losses from the time of germination aggregate 82 percent. The 12 living seedlings divide equally as to grade, 6 are rated poor and 6 fair. Those rated as poor indicate, by their appearance, that they will soon die; certainly none of them can live to produce fruit. The 6 better trees now graded as fair may survive to fruiting, altho even the best individual has, by its growth performance, exhibited vitality much below that possessed by normal seedlings. Thus of 67 seedlings produced in this group of crosses, 6 have a possible chance of survival to fruit production.

The records of the behavior of all crosses having *M. soulardii* as the female parent are brought together in Table 6.

No attempt has been made to use *M. soulardii* as the male parent.

The Mercer County Crab

This Mercer County Crab is not given specific rank, but it is of the type of *M. soulardii* and without doubt is closely related to it, as it originated in the same way and is native in the same region. Breeding tests with this crab may follow those given for *M. soulardii*.

The Mercer County Crab was used as the female parent in 8

TABLE 6.—*Malus soulardii* AS FEMALE

crosses by 5 orchard varieties and 1 crab-form, all made in the greenhouse in the years 1913 to 1918.

The 1913 cross by Yellow Transparent yielded 4 fruits from 11 pollinations; thus 36.36 percent of the pollinations were successful in fruit production. The 4 fruits contained 14 seeds, an average of 3.5 to each fruit. Nine of the seeds germinated; 3 seedlings lived to be planted in nursery, but the last one died in the fourth year.

A 1914 cross by Grimes matured 1 fruit from 9 pollinations; this fruit contained 3 seeds, 1 of which germinated, but the seedling did not live to be planted in nursery. One other cross, that by Fanny in 1917, matured 1 fruit from 23 pollinations; this fruit also contained 3 seeds, but none germinated. The other 5 crosses failed to produce fruits.

The total number of pollinations in the 8 crosses was 81. Three of the crosses matured 6 fruits, representing 7.4 percent of the pollinations. The 6 fruits contained 20 seeds, 10 of which germinated, but only 3 seedlings lived to be planted in nursery and the last of these died before the end of the fourth year.

The Mercer County Crab was used as the male parent in 5 greenhouse crosses, 4 on orchard varieties and 1 on the crab-form *M. ringo*. The crosses on orchard varieties all failed, but the one on the crab was 47.83 percent successful, 11 fruits maturing from 23 pollinations. The 11 fruits contained 25 seeds, 13 of which germinated. Seven of the seedlings were planted in nursery; 3 of these died the first year, 1 the second, and 1 the third year.

The two remaining trees, now eleven years old, are widely different. One of these trees has been weak from the beginning and its growth increments are very small; it is now 3 feet 8 inches in height, spreads 4 feet 2 inches, and has a trunk diameter of .8 inch; it belongs in the class of other seedlings that have died and will probably end its struggle for existence this year. The other seedling has, from the time of germination, given evidence of the possession of vitality; growth has been good and it is now 10 feet 5 inches high, spreads 12 feet 2 inches, and has a trunk diameter of 6 inches. The tree is symmetrical, somewhat spreading as are both its parents. The branches are quite smooth and the bark dark reddish-brown, as in *M. ringo*. It has not yet fruited, but is expected to produce flowers either this year or next. On the expected death of the weak tree, this vigorous, well-developed tree will stand as the only representative of a cross having the Mercer County Crab as a male parent.

5. *Malus fusca* (Rafin.) Schneider

M. fusca is the Oregon Crab Apple, native on the Pacific Coast from Sonoma county, California, northward along the coast thru Oregon and Washington to Alaska. It appeared for many years under the name *Pyrus rivularis*, as published by Douglas in Hooker's "Flora of

North America," but this name was finally superseded by *fusca* as being an earlier name applied by Rafinesque.

This western species is totally different from the native species growing east of the Rocky Mountains. Its affinities are nearer to Siberian species than to other North American species. The tree is said to grow from 15 to 25 feet high, but frequently takes the form of a many-stemmed shrub. The leaves are small and of various forms; many are ovate in outline, acute or acuminate, often more or less lobed; margins are sharply serrate, or on some leaves crenate. As grown at this Station from scions received from the Arnold Arboretum, the tree is decidedly dwarf in appearance and of very slow growth. One tree from a root-graft made in January, 1908, as measured in the fall of 1924, when seventeen years old, was 9 feet 6 inches high, had a spread of 5 feet 4 inches, and a trunk diameter of 2.9 inches. Another tree from a top-graft inserted April 7, 1908, on a Virginia Crab seedling measured, in October, 1925, at eighteen years from graft, 13 feet 2 inches high, had a spread of 11 feet, and a trunk diameter of 5.8 inches. In general the direction of branches is erect, becoming more spreading with age.

This species flowers from terminal mixed buds and to some extent from lateral buds on terminal shoots. The inflorescence is corymbose, with from 9 to 13 flower buds in each cluster. In most buds the axis elongates somewhat, giving the cluster a racemose appearance. Individual flower buds are small, white, and tinged pink. Flowers expand from 13 to 18 mm. and are pure white. Pedicels are slender, 16 mm. to 20 mm. long, each with 1 to 3 linear bracts; slightly pubescent, as is also the ovary and the exterior surface of the small, obtusely triangular calyx lobes. Petals are 5 to 7 mm. long by 3 to 5 mm. broad, mostly rounded, and inclined to be cordate, claw very short. Stamens 16 to 20, filaments slender, 3 to 5 mm. long; anthers large, plump, creamy white. Pollen grains large, elliptical, almost white. Styles 3 or 4, slender, 4 mm. long, connate half the length, glabrous, tips compressed. Stigmas oval or elliptical. Ovary 3- or 4-celled. Flowers fragrant. Fruits small, oblong, cylindrical or ovoid in form. Of 22 fruits weighed and measured, the average weighs one-half gram; the average vertical diameter is 10 mm., the transverse diameter 9 mm. The color is self-yellow or with a bronze or red blush on one side. Each fruit has either 3 or 4 carpels with 2 ovules in each, but the average of developed seeds is 1.32 to each fruit, the lowest seed average of any species of *Malus* examined. The seeds are very small, only two species have seeds of less size, namely, *M. sargentii* and *M. toronto*.

Malus fusca as the Female Parent

M. fusca has been used as the female parent in 3 crosses. In 1916 Jonathan pollen was used to pollinate 117 flowers; 11 fruits, repre-

senting 9.4 percent of the pollinations, matured. These 11 fruits contained 13 seeds, 3 of which germinated, and the seedlings completed their ninth year in 1925. In the growth record for 1925 the trees have dimensions and ratings as follows:

Cross No.	Height	Spread	Diameter	Rated as
11383-1.....	2 ft. 2 in.	2 ft. 2 in.	.9 in.	"poor"
11383-2.....	8 ft. 8 in.	6 ft. 8 in.	2.7 in.	"good"
11383-3-2.....	9 ft. 11 in.	9 ft. 4 in.	3.0 in.	"good"

For trees nine years old the dimensions are small, and the larger tree is over four times the height of the smaller and has more than three times the diameter. With most crosses an individual but little over 2 feet tall at the end of nine years would be looked upon as meaning the end of its existence, but in this cross the usually dwarf growth of the female parent should be considered, and as the smallest tree of this group has appearance of health, it may be expected that all of the trees will live to produce fruit. The diminutive size may be ascribed to inheritance of the dwarf habit of the female parent.

In the following year, 1917, Oldenburg pollen was applied to stigmas of 121 flowers, and one fruit matured. This fruit contained one seed; the seed germinated, but the seedling died before time to transplant to nursery. Thus this cross failed entirely.

Again in 1921 pollen of Rome was used to pollinate 57 flowers of *M. fusca*; 6 fruits matured, representing 10.53 percent of the pollinations. The six fruits contained 8 seeds, only 2 of which germinated. The two seedlings were planted in nursery, and one of them died before the end of the first season. The remaining seedling is now four years old, has been two years in orchard, and in the growth record of 1925 is recorded as 2 feet 2 inches in height, having a spread of 3 feet, a trunk diameter of .8 inch, and is graded as good.

Thus at the end of 1925 there were in orchard 4 seedlings from crosses in which *M. fusca* was the female parent—3 from the 1916 cross by Jonathan and 1 from the 1921 cross by Rome. None of these seedlings have fruited; they are all small and more or less dwarfed in appearance, but all are healthy and it is expected that they will live to bear fruit. The use thus far made of *M. fusca* as a female parent is too limited to serve as a basis upon which to form judgment as to the real value of the species for breeding purposes, but from the low percentage of pollinations maturing fruit, the low seed content of the hybrid fruits, and the slow growth of the seedlings, there is little to encourage belief in successful use of this species.

The use of *M. fusca* as the male parent has not been attempted.

6. *Malus dawsoniana* Rehder

This species was described in 1913 as a hybrid between *M. fusca* and the common apple. The tree was grown at the Arnold Arboretum from seeds of *M. fusca* collected by C. G. Pringle in Oregon in 1881.

The general habit of growth resembles that of *M. fusca*, but the tree is much more vigorous, has a tendency to the production of numerous branches, and thus forms a very dense crown. Leaves are dark green, ovate or oval in form, larger than leaves of *M. fusca* and less inclined to be lobed; they are pubescent when young, becoming glabrous when mature. Flowers are borne from terminal buds of terminal twigs and spurs. Flowers range from 5 to 13 to the cluster, but usually the number is from 8 to 10; they are pure white, and expand from 32 to 35 mm. as compared with 13 to 18 mm. for flowers of *M. fusca*. Fruits of *M. dawsoniana* are considerably larger than fruits of *M. fusca* and different in form, being oval-oblong or often obovate-oblong. Differences in fruits of the two species can be most clearly shown by arranging available records in tabular form as below.

	Number of fruits	Average number of good seeds	Average weight in grams	Average vertical diameter in mm.	Average transverse diameter in mm.
841 <i>M. fusca</i>	72	2.00	.508	9.26	8.69
842 <i>M. dawsoniana</i> ..	379	2.90	11.74	31.73	26.36

Calyx lobes of *M. fusca* are deciduous in all fruits. *M. dawsoniana* has persistent calyx lobes in nearly all fruits, but an occasional fruit is found that has the calyx lobes deciduous in the regular manner. Color of the fruit of *M. dawsoniana* as grown here is usually a greenish-yellow and there are occasional fruits having a bright red blush on one cheek; this feature, however, appears to vary in different seasons, being sometimes rare and in some seasons common.

Only one cross has been attempted with *M. dawsoniana* as the female parent. This was in 1918 when, on May 6, 69 flowers, which had been emasculated on May 3, were pollinated with Jonathan pollen. No fruits developed.

Self-Pollinations of Apple Forms

Native Crabs.—It has been the intention to self-pollinate some flowers on each of the apple forms used in the breeding work in order to test their relative self-sterility or self-fertility. This work has been done as opportunity offered; it has not yet included all forms and is not nearly so extensive as is desired. Some flowers have been self-pollinated on each of five of the species of native crabs, but the Pacific Coast species, *M. fusca*, has not been tested, chiefly because it flowers much later than other forms and attention to the blossoms at the proper time has been crowded out by other work.

Summarizing the self-pollinations made on the five native crabs, it appears that an aggregate of 840 flowers were self-pollinated in eleven of the thirteen years of the period 1914 to 1926.

M. coronaria from 4 self-pollinations in 1918 developed 3 fruits containing 9 seeds, none of which germinated, and the 72 self-pollinations of 1926 matured no fruits.

On *M. ioensis* the 287 self-pollinations were distributed over four years; from the 114 self-pollinations of 1917 one fruit containing 2 seeds developed, and from the 47 self-pollinations in 1926 two fruits with 3 seeds matured, but none of these seeds germinated.

On *M. soulardi* 264 self-pollinations were made in eight efforts in seven years, but no fruits matured, and there was the same complete failure for 92 self-pollinations, distributed over three years, on the Mercer County Crab.

Thus these four species, *coronaria*, *ioensis*, *soulardi*, and the Mercer County Crab, tested thru 712 self-pollinations, register complete failure to produce viable seeds and are therefore completely self-sterile so far as efforts thus far made are concerned.

The remaining species, *M. dawsoniana*, saves the whole effort in self-pollination of native crabs from complete failure by the production of one seedling. The 48 self-pollinations of 1925 matured no fruit; the 73 self-pollinations of 1926 matured 2 fruits; one of these contained 1 seed, which did not germinate, the other contained 3 seeds, one of which germinated. This seedling from seed planted in December, 1926, and stored in a pit thru the winter, appeared above ground on March 31 and at the time of shifting to the nursery on June 6, 1927, while not so tall as many seedlings in groups from crosses, was healthy and appeared to possess vigor equal to that of its parent.

This seedling will be watched with interest as being the only product from the self-pollination of a native crab.

This test of self-fertility leads to the conclusion that native crabs are self-sterile to such degree as to constitute an effective bar to the attainment of a generation of seedlings from self-pollinations; and yet, having observed the wide seasonal variations to which all apple forms are subject, there is hesitation in declaring that native crabs are habitually self-sterile. It is thought that self-pollination of a much larger number of flowers carried on thru an additional series of years on trees grown under other and, possibly, slightly different conditions might lead to results different from those here recorded. In any event, such procedure would supply a much more stable basis upon which conclusions regarding the actual degree of self-sterility attaching to our native crab forms could rest.

Introduced Forms.—In order to avoid giving the impression that self-sterility, as an attribute of apple forms, is possessed solely by our native species, reference should here be made to self-pollination of flowers on the much larger group of introduced crabs or crab-like forms of apples.

Flowers have been self-pollinated on 38 of the foreign crab forms in the Station collection. These self-pollinations aggregate 10,511 and were distributed thru the fifteen years 1912 to 1926.

TABLE 7.—SELF-POLLINATION OF FLOWERS OF NATIVE CRABS

Species	Year	Number of flowers selfed	Number of fruits matured	Number of seeds		Number of seedlings living
				Planted	Germi- nated	
<i>Malus coronaria</i> . . .	1918	4	3	9	0	..
	1926	72	0	..	..	..
<i>Malus ioensis</i>	1917	114	1	2	0	..
	1921	76	0	..	..	..
	1925	50	0	..	..	..
	1926	47	2	3	0	..
<i>Malus soulardii</i>	1914	11	0	..	..	..
	1916	4	0	..	..	..
	1917	5	0	..	..	..
	1917	128	0	..	..	..
	1918	6	0	..	..	..
	1922	39	0	..	..	..
	1924	21	0	..	..	..
	1926	50	0	..	..	..
Mercer County Crab.	1919	14	0	..	..	..
	1920	30	0	..	..	..
	1922	48	0	..	..	..
<i>Malus dawsoniana</i> .	1925	48	0	4	1	1
	1926	73	2	4	1	1

Twelve forms, with 1,744 self-pollinations, matured no fruits; 3 forms, with 690 self-pollinations, produced 7 fruits that were seedless; 2 forms, with 225 self-pollinations, matured 5 fruits containing 4 seeds, none of which germinated; 2 forms, with 601 self-pollinations, produced 7 fruits containing 2 seeds, both of which germinated, but the seedlings, having no vitality, died soon after appearing above ground; 2 forms, with 1,487 self-pollinations, produced 373 fruits containing 819 seeds, 29 of which germinated, and 19 seedlings lived to be transferred to nursery, but all died before the end of the first year.

Thus 21 of the 38 foreign crab forms, representing 45.16 percent of the total of self-pollinations on members of the foreign crab group, failed and have no seedlings from self-pollinations. The aggregate of self-pollinations on the 21 forms recorded as failing completely was 4,747. From these, 392 fruits matured. The fruits contained 830 seeds, only 31 of which germinated; the seedlings were so deficient in vitality that they could not live and all died within a few months.

Each of the remaining 17 forms of this group of introduced crab forms is represented by one or more seedlings grown from fruits from

self-pollinations. Nine of the forms hold representation in this group, each thru a single seedling, and each of the nine is thus quite liable to elimination thru death of its one seedling.

This group contained 103 seedlings. These seedlings represent the product from the self-pollination of 5,764 flowers, which matured 548 fruits containing 1,533 seeds, of which 425 germinated. That most of the seedlings were deficient in vitality is shown by the fact that nearly 76 percent of them have died and that a considerable number of those still living are graded as poor.

Only two of the forms in the group have shown what may be regarded as a certain degree of self-fertility. With each of the two forms this tendency to an exhibition of self-fertility occurred in only one of several years, and the year of high production was not the same for both forms. One of the forms referred to is 19651 *M. prunifolia* var., which, while it failed with 17 self-pollinations in 1916, with 23 in 1918, with 90 in 1919, and from 316 self-pollinations in the greenhouse in 1917 produced one seedless fruit, did, from 120 self-pollinations on a tree in orchard in 1917, mature 112 fruits, or was 93.33 percent successful in fruit production. The 112 fruits contained 637 seeds, of which 176, or 27.62 percent, germinated; 114 seedlings were transferred to nursery, 26 of which were living in the fall of 1926 at nine years of age. Eleven of the seedlings graded as good and are quite certain to attain fruit production; 9 are graded as fair and are regarded as doubtful; 6 are graded as poor and are expected to die before fruiting. The other of the two forms appearing to be in a degree self-fertile, in one of the nine years over which the aggregate of 405 self-pollinations are distributed, is 19644 *M. microcarpa*. In six of the years, with a total of 189 self-pollinations, no fruits were matured. In 1917 the self-pollinations numbered 95, and they matured 4 fruits containing 4 seeds, which did not germinate. In 1918 there were 51 self-pollinations, which matured 6 fruits containing 1 seed; this seed germinated, but the seedling died soon after appearing above ground. In 1925 one of 32 self-pollinations matured a fruit, but it was seedless. On a greenhouse tree in 1919, however, 38 self-pollinations matured 21 fruits; thus 55.26 percent of the self-pollinations were successful in fruit production. The 21 fruits contained 66 seeds, 49, or 74.24 percent, of which germinated, and 44 seedlings were transferred to nursery. Of these seedlings 32 were living in the fall of 1926 at seven years of age; they graded as 7 good, 19 fair, and 6 poor, and as with the seedlings from self-pollinations on 19651 *M. prunifolia* var., those grading good are expected to fruit, those grading fair must be regarded as doubtful, and those grading poor are quite certain to die before reaching fruit production.

The form standing next below the two forms mentioned in number of living seedlings from self-pollinations is 19667 *M. malus* var.

There are 13 seedlings, but instead of being the product of self-pollinations of a single season, they are from self-pollinations made in four years. One seedling is eleven years old from self-pollinations made in 1915; 7 are nine years old from self-pollinations of 1917; 4 are seven years old from self-pollinations made in 1919; and 1 is two years old from self-pollinations of 1924. At the time of taking the growth record in the fall of 1926 not one of the seedlings was rated as good; the eleven-year-old tree was poor; of the 7 completing their ninth year 6 rated poor and 1 fair; the 4 at seven years of age rated as 2 poor and 2 fair, and the tree two years old was poor. Thus for the group 10 graded as poor and 3 as fair; none of the seedlings were vigorous. While the percentage of fruit production was 50.54, the seed content of 2.44 to each fruit was low, germination was only 21.40 percent, and the seedlings were of low vitality, as is shown by the fact that almost 90 percent have died and 77 percent of those living are graded as poor and these will certainly die before attaining fruit production.

This group would appear not to be entitled to credit for any degree of self-fertility, and the elimination of the group before any of the seedlings reach fruit production is anticipated. There are five others in this group of foreign crabs that have no seedlings graded as good, and the six forms may properly be added to the 21 forms that are not represented by seedlings, making 27 forms that have failed in this test of self-fertility and should be classed as self-sterile. Only 11 forms have seedlings that grade as good and 7 of these are represented by a single individual each.

From the record of self-pollinations on foreign crab forms it appears that forms included within the groups are, as a rule, self-sterile. Exceptions occur, but in no form do they occur with sufficient regularity to make the form useful in breeding operations.

Comparing the two groups of crab forms, the native with the foreign, there is little, if any difference between them. Members of both groups are, in the main, self-sterile.

A third group of apple forms, which includes the named varieties commonly planted in orchards, may be included as part of the survey of self-pollinations.

On 35 orchard varieties 3,485 flowers have been self-pollinated. Twenty varieties produced no fruit; 4 varieties produced 1 seedless apple each; 1 variety produced one fruit which had one seed, and the seed failed to germinate; in another case the one seed produced germinated but the seedling died. Thus 26 varieties have no living seedlings from self-pollinations.

Nine varieties are represented by living seedlings, but as a matter of fact only two varieties have seedlings in sufficient numbers and of such quality as to suggest possession of any appreciable degree of

self-fertility. These two varieties are Longfield, a Russian variety, and Wythe, which originated as a seedling in this state.

Orchard Varieties.—Considering orchard varieties as a group, the results obtained from self-pollinations are much the same as results obtained with the two crab groups, and thus one general statement to the effect that apple forms are self-sterile is warranted. In the eighteen years beginning with 1909 and ending with 1926, a total of 14,836 flowers have been self-pollinated on 78 different apple forms. At the end of 1926 there were 27 forms represented by living seedlings. Fifty-one forms are therefore recorded as failing entirely. The living seedlings produced by 27 apple forms from self-pollinations number 252, but only about one of five is graded as good and experience has taught that seedlings that, because deficient in vigor, grade as poor or fair are not likely to attain fruit production altho they sometimes linger for several years.

The 51 seedlings now graded as good include some that are still very young and for this reason some decrease in numbers in this group may be anticipated.

Conclusions.—Rarely do seedlings grown from seeds developed in fruits from self-pollinations possess normal vigor; most of them are endowed with so little vigor that they cannot live, and they die more or less promptly. The few that persist and promise attainment of fruit production serve to emphasize and make clear the uncertainties and difficulties that must attend any effort to produce a generation of seedlings from a sufficient number of self-pollinations to make it possible to determine accurately the principles involved in the production of seedlings by this method in apple forms.

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